

Claims

1. An immobilization method, comprising the steps of:
carrying out electrospray such that a solution containing at least
one objective substance is supplied into a capillary and an electric
5 voltage is then applied on the solution to allow electrostatic
atomization thereof, and

carrying out immobilization such that the objective substance in
the solution atomized in the step of carrying out the electrospray is
immobilized on an object, which is to be coated and has an arbitrary
10 shape, in a dried state by an electrostatic force while retaining
functionality and/or activity of the objective substance to form a dried
microstructure having a thickness on the order of nanometers.

2. The immobilization method as described in claim 1, further
comprising the step of, before the step of carrying out electrospray,
15 adjusting the average particle size of the objective substance contained
in the solution.

3. The immobilization method as described in claim 1 or 2,
wherein, before the step of carrying out electrospray, the solution is
prepared by dissolving or dispersing an objective substance having a
20 predetermined average molecular weight.

4. The immobilization method as described in claim 1, wherein
the electrospray step also comprises the steps of previously
defining, on the basis of a kind of the solution, an analytical curve
representing a relationship between a duration of electrostatic
25 atomization and a thickness of the microstructure, using the analytical
curve corresponding to the kind of the solution used to define the
duration of the electrostatic atomization depending on a desired film
thickness.

5. The immobilization method as described in claim 1, wherein
30 the object to be coated is one of a substrate having at least
slight electrical conductivity, a film, a polygonal column-shaped
member, a cylindrical member, a fine particle, a globular substance, or
a porous body.

6. The immobilization method as described in claim 1, wherein the object to be coated is insulative, and the immobilization method further comprises the step of supplying ionic wind generated by means of an ion generator to a microstructure on the object to be coated to remove electricity.

7. The immobilization method as described in claim 1, wherein the electrospray step uses as the objective substance a substance suitable for the formation of a fiber, and the objective substance is then electrostatically atomized to form a fibrous microstructure, and the immobilization step immobilizes the fibrous microstructure on the object to be coated.

8. The immobilization method as described in claim 7, wherein the material suitable for the formation of the fiber is a linear polymer.

9. The immobilization method as described in claim 7 or 8, wherein

the object to be coated is a polygonal column-shaped member or a cylindrical member, and

a step of winding up the fibrous microstructure on the surface of the object to be coated by rotating the object to be coated is also comprised.

10. The immobilization method as described in claim 1, wherein the electrospray step also comprises at least one of the steps of shifting the capillary, changing the direction of spray by arbitrarily changing the angle of the capillary, or shifting the object to be coated.

11. The immobilization method as described in claim 1, wherein the electrospray step also comprises the step of oscillating the capillary.

12. The immobilization method as described in claim 1, wherein the electrostatic atomization in the electrospray step is carried out using a capillary having a tip portion of 100 μm or more in inner diameter.

13. The immobilization method as described in claim 1, wherein the electrospray step comprises the steps of performing the electrostatic atomization while providing a minute range of a periodic change in voltage applied on the solution to distinguish an electro-
5 static atomization state and a gas discharging state, and monitors an amount of change in current value of the solution using an ampere meter.

14. The immobilization method as described in claim 1, wherein the electrospray step comprises any of the steps of adjusting the
10 pressure of the solution when the solution is supplied to the capillary, adjusting the flow rate of the solution, or adjusting so as to establish a constant relational expression between the pressure and the flow rate of the solution.

15. The immobilization method as described in claim 1, wherein
15 the electrospray step comprises any of the steps of adjusting a voltage at constant when the voltage is applied on the solution, adjusting the voltage so that a current passing through the solution becomes constant, or adjusting the voltage to establish a constant relationship between the voltage and the current.

20 16. The immobilization method as described in claim 1, wherein the raw material of the capillary is any of a metal, glass, silicon, or synthesized polymer material.

17. The immobilization method as described in claim 1, wherein when multiple capillaries are provided, the electrospray step also
25 comprises the step of adjusting each of a voltage or a current supplied to the solution contained in each of the capillaries to an optimal value.

18. The immobilization method as described in claim 1, wherein multiple capillaries are provided, and the electrospray step comprises the step of dividing the solution to supply the solution to
30 the multiple capillaries by use of a connector having the same number of output tubes as that of the capillaries per a single input tube, where each of the output tubes has its major axis inclined at the same angle as that of the major axis of the input tube.

19. The immobilization method as described in claim 1, wherein multiple capillaries are provided and each of the capillaries is connected with multiple tubes having their own valves, and

the electrospray step comprises the step of individually opening
5 or closing the valve to concentrate a pressure force of the solution to at least only one of the capillaries so that degassing and/or dipping can be easily performed.

20. The immobilization method as described in claim 1, wherein the voltage applied on the solution is intermittently supplied.

10 21. The immobilization method as described in claim 1, wherein a portion to be touched with the solution and/or the electrostatically atomized objective substance is tolerative with respect to the solution and/or the objective substance.

22. The immobilization method as described in claim 1, further
15 comprising the step of:

using at least one of a collimator electrode, means for supplying an ion flow, or means for supplying a pressure air, to converge the objective substance electrostatically atomized in the electrospray step.

23. The immobilization method as described in claim 1, further
20 comprising the step of:

surrounding a space in which at least both the electrostatic atomization and the immobilization is carried out and then supplying inert gas and/or clean dry air into the case.

24. The immobilization method as described in claim 23, further
25 comprising the step of:

carrying out pressure reduction or evacuation in the inside of the case.

25. An immobilization apparatus, comprising:

means for electrospraying, by which a solution containing at least
30 one objective substance is supplied into a capillary and an electric voltage is then applied on the solution to allow electrostatic atomization thereof;

means for supporting an object, which is to be coated and has an

arbitrary shape, on which the objective substance is immobilized in a dried state by an electrostatic force while retaining functionality and activity of the objective substance to form a dried microstructure having a thickness on the order of nanometers; and

5 at least one of means for shifting the capillary, means for changing the angle of the capillary to an arbitrary angle, or means for shifting the object to be coated.

26. The immobilization apparatus as described in claim 25, wherein

10 the means for electro spraying performs electrostatic atomization while providing a minute range of a periodic change in voltage applied on the solution, and

 the immobilization apparatus further includes means for measuring a current, which monitors an amount of change in current
15 value of the solution.

27. A method of manufacturing a microstructure having a thickness on the order of nanometers, comprising the steps of:

 carrying out electrospray by which a solution containing at least one objective substance suitable for the formation of a fiber is
20 supplied into a capillary and an electric voltage is then applied on the solution to allow electrostatic atomization thereof; and

 electrostatically immobilizing the objective substance in the solution atomized by the electrospray step on an object, which is to be coated and has an arbitrary shape, in the dry state while retaining the
25 functionality and/or activity of the objective substance to form a dried fibrous microstructure having a thickness on the order of nanometers.